1 9 0045

# INVESTIGATION OF GROUND WATER AT
# SOUTH CAROLINA RECYCLING AND DISPOSAL COMPANY
# BLUFF ROAD SITE, RICHLAND COUNTY
# SOUTH CAROLINA

PREPARED BY

GROUND-WATER PROTECTION DIVISION

BUREAU OF WATER SUPPLY AND SPECIAL PROGRAMS

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

COLUMBIA, SOUTH CAROLINA

JANUARY 1981

1 9 0046

CONTENTS

# LIST OF FIGURES AND TABLES

1 9 0048

LIST OF FIGURES AND TABLES (cont'd)

1 9 0049

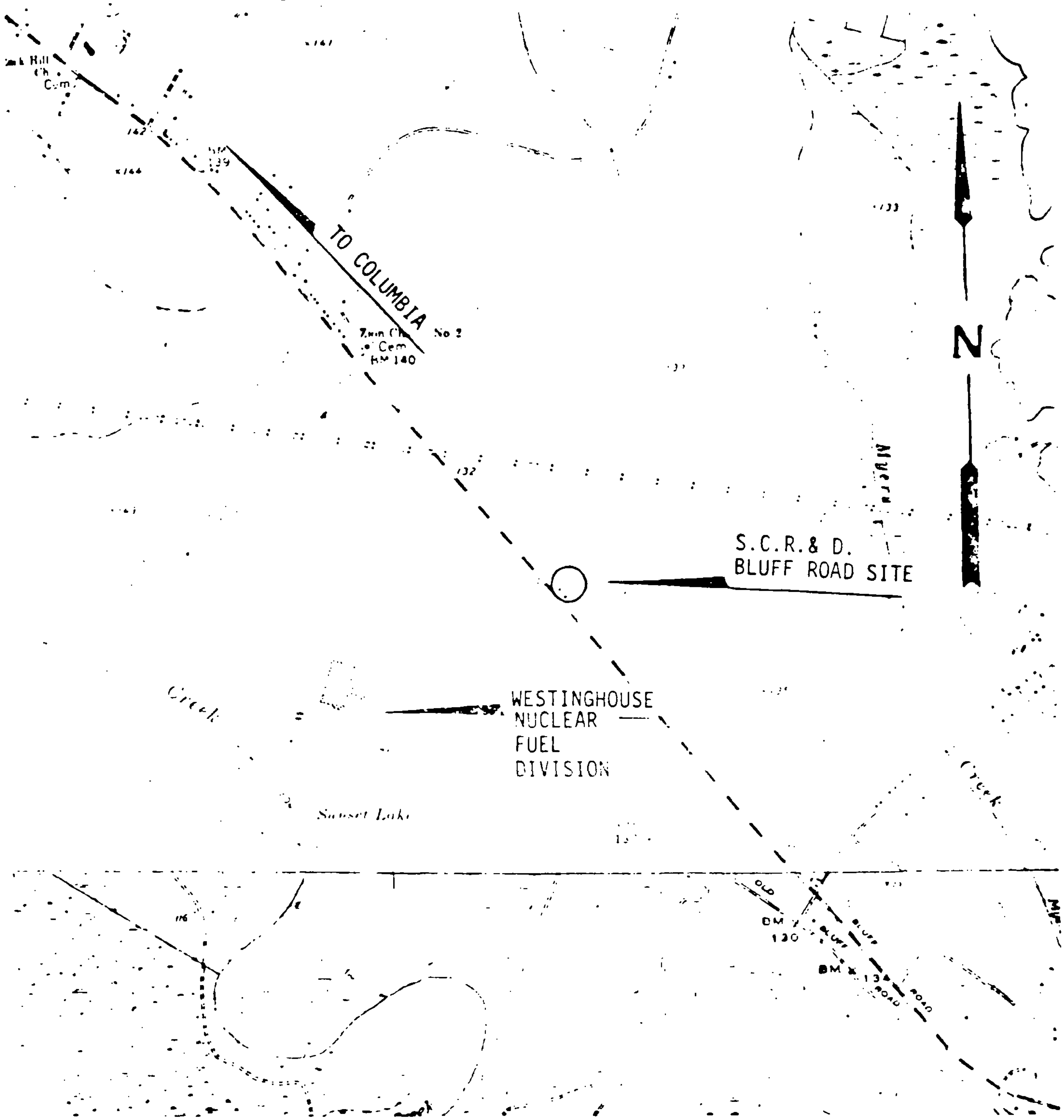
# INVESTIGATION OF GROUND WATER AT SOUTH CAROLINA RECYCLING AND DISPOSAL COMPANY BLUFF ROAD SITE, RICHLAND COUNTY SOUTH CAROLINA

## BACKGROUND, PURPOSE, AND SCOPE

The South Carolina Recycling and Disposal (S.C.R.& D.) Bluff Road site is located in Richland County approximately ten miles (16 km) southeast of Columbia (figures 1 and 2), northeast of Bluff Road (South Carolina Highway 48). S.C.R.& D. began storing chemicals at the site in 1976. Previously the site had been a marshalling site for Columbia Organic Chemicals, a parent company to S.C.R.& D.. First reference in the Solid and Hazardous Waste Management Bureau files to the site is dated 1975. According to information furnished the U.S. Environmental Protection Agency (USEPA) by Mr. James McClure, President of S.C.R.& D., an acetylene manufacturing facility was originally located at the site but no detailed information was available. The site contains barrels and other containers of various waste chemicals. Many of the barrels were moved to the Bluff Road site from the company's Dixiana and Dreyfus Street storage sites.

A reconnaissance sampling of ground water and surface water in the vicinity of the Bluff Road site was conducted by USEPA, Surveillance and Analysis Division, Athens, Georgia, during March 17-18 of 1980. A report, <u>Groundwater and Surface Water Investigation South Carolina Recycling and Disposal, Inc., Bluff Road Site, Columbia, South Carolina July 1, 1980</u>, was prepared. The report described the study area, sampling methods, and results. Several items noted in the report concerning practices at the site include; "Drums of waste chemicals (acetone, ethyl alcohol, freon,

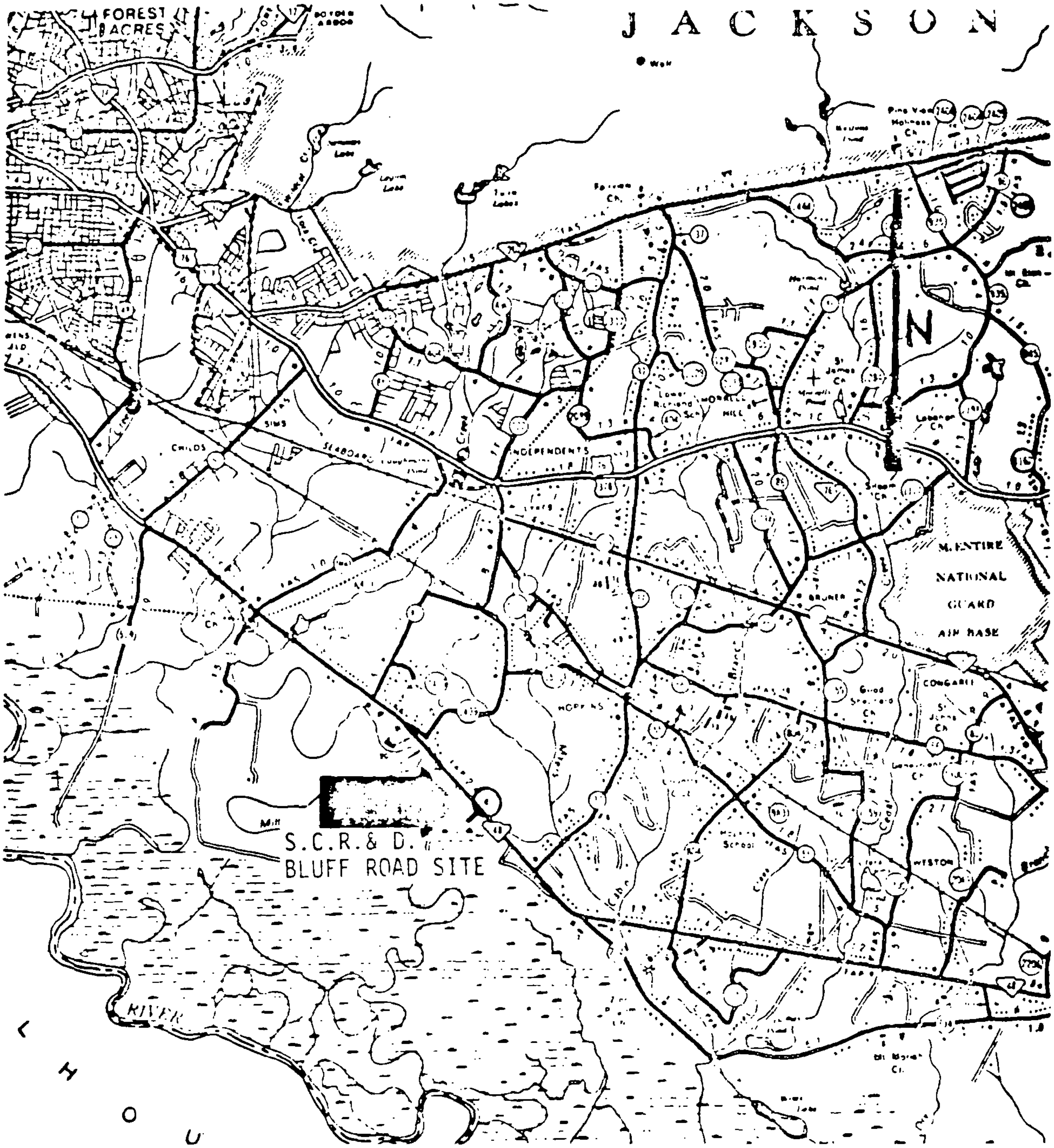
1 9 0050




Scale-1"=2000 feet.
Taken from U.S.G.S. 7½ minute series Fort Jackson South 1972 and Saylors Lake 1972 maps.

Figure 1. Location map, S.C.R.& D. Bluff Road Site.

1 9 0051




Scale-1"= 2 miles
Taken from SCDHPT General Highway Map of Richland County.

Figure 2. Location map S.C.R.& D. Bluff Road Site in Richland County.

and perchloroethylene) and empty one gallon jugs (formerly containing reagent grade trichloroethylene) were stored on the highway right-of-way ... numerous examples of spillage and/or leaking drums in the drum storage area .... Drums of zirconium tetrachloride stored near the lagoons have disintegrated .... active zirconium tetrachloride is still exposed on the ground surface."

USEPA analysis of soil samples from the surface indicated high levels of metals (titanium, vanadium, zirconium, calcium, aluminum, iron, and sodium). The soil analyses also revealed the presence of various organic compounds. "The occurrence of all of the above compounds at SCR-2, SCR-3, and SCR-4 are not surprising when the amounts of observed spillage around each of these sites are considered."

As part of the USEPA study, ground-water samples were collected from three existing wells. Two of the wells are at or adjacent to the site (inside the warehouse, and at Campbell's Garage), while the third well is located off-site, approximately 1.3 miles (2.1 km.) to the north. Analyses of water samples from the wells indicated that none of the wells exceeded primary drinking water standards for metals. The warehouse well did have a lead concentration of 0.047 milligrams per liter (mg/l) which approaches the primary drinking water standard of 0.05 mg/l. Dieldrin, a common pesticide, was detected in low concentrations in the well at Campbell's Garage. The report concluded that "Since dieldrin was not detected in any of the other samples (soil, sediment, or water) collected in and around this site, its occurrence in the sample from CG1 is probably the result of localized practices such as termite control."

On June 13 of 1980, USEPA sent the owner of Campbell's Garage a letter advising of the analytical results. The letter advised that while the concentrations found did not present a significant short-term health hazard, an alternate water source should be obtained.

The purpose of this investigation which began on August 8, 1980, was to provide a further assessment of ground-water conditions in the water-table aquifer and the impact of the storage facility on nearby potable water-supply wells.

The scope of this investigation included the drilling and construction of eleven two-inch (5-cm) diameter wells, measuring water levels and specific conductance, and the sampling of the wells, including the two existing wells. Shallow horizontal ground-water flow direction was determined. Preliminary sampling was completed September 22, 1980. The data were evaluated and recommendations developed.

The field investigation was made by Raymond L. Knox and Thomas M. Champion, Geologists, under the direction of James M. Ferguson, Section Manager, and Donald A. Duncan, Director, Ground-Water Protection Division. Laboratory analyses were made by the South Carolina Department of Health and Environmental Control (SCDHEC) under the direction of Alfreda Mouchet and Anthony Williams. Field surveying of well elevations was made by Fred Soland, P.E.

## METHODS

In order to determine the hydrogeologic characteristics of the site (geology, direction of ground-water flow, water quality, etc.), a network of eleven wells was constructed. Data from two existing wells, the water supply well at Campbell's Garage and a monitoring well at the Westinghouse Nuclear Fuel Division, were also incorporated in the study.

Field methods used in the study included; drilling and logging of cuttings, well construction, development, and sampling; surveying to determine relative elevations of wells, and measurement of water levels. The monitoring wells were numbered according to a statewide grid system and in the chronological order in which they were drilled. The wells within the study grid (G26-f) will be identified in this report by sequential numbers only. Wells 1, 2, and 3 were drilled with a Mobile B-34 drill using four-inch (10-cm) diameter continuous-flight auger. Lithologies were described for each of these boreholes from the disturbed cuttings. Each stratum was recorded and the percentage of each grain size observed was estimated. The rotational pressure, in pounds per square inch, was also logged in order to more accurately determine the depth at which each stratum change occurred.

Wells 4 through 11 were drilled with a four-inch (10-cm) diameter bucket-type hand auger. This method was used because of site inaccessibility to motorized equipment. The cuttings were logged and the grain size distribution estimated.

Two-inch (5-cm) diameter PVC well casing was placed into each borehole. The bottom three to five feet (0.9 to 1.5 m) of the casing were two-inch (5-cm) diameter, schedule eighty, #10 slot (.010-inch) PVC horizontally-slotted well screen, capped at the bottom. A clean coarse sand and gravel was placed by gravity filling in the annular space of each well along the entire length of the well screen. A bentonite-pellet seal approximately one foot (0.3 m) in length was placed in the annular space above the well screen. The remainder of the annular space was then backfilled with cuttings from the drilling of the borehole. The ~~wells~~ were capped with a PVC cap to prevent exposure to outside influences.

All wells were developed by surging and interrupted pumping. A valved drop pipe attached to a hand-operated pump was used as a surge block. This technique provided the ability to both surge the well and pump the agitated fine material to the surface. When this procedure was completed, the wells were pumped for approximately thirty minutes with a gasoline-powered centrifugal pump.

Well elevations were surveyed by a registered professional engineer using standard engineering techniques. Water levels were allowed to stabilize for a minimum of twenty-four hours and measured periodically over several weeks by lowering a chalked, weighted steel tape into the well. Five maps (figs. 13-17) showing the water-table surface were drawn so that changes in the direction of horizontal ground-water flow could be detected.

Specific conductance (S.C.) was measured in each well using a Yellow Springs Instrument portable conductivity meter. S.C. measurements were made during development and sampling by suspending the probe in the pump-discharge stream. After development and sampling, S.C. was measured by lowering the probe into the well. Since some stratification of water quality in each well had occurred, the range of measurements was recorded.

The wells were pumped with a gasoline-powered centrifugal pump for approximately one-half hour before the samples were collected to obtain a representative sample of formation water. The samples were placed in appropriate containers, packed in ice, and taken immediately to the DHEC laboratory for analysis.

# DATA

The lithologic logs, construction information, locations, and analytical results are shown in figures 3 through 10 and in tables 1 through 3. Water-table-surface contour maps indicating direction of flow are shown in figures 13 through 17. Wells containing volatile organics are shown in figure 12. Inorganic analyses are shown in table 2. The volatile organics detected in laboratory analyses are listed in table 3. Table 4 contains water table elevations for the study period.

1 9 0057

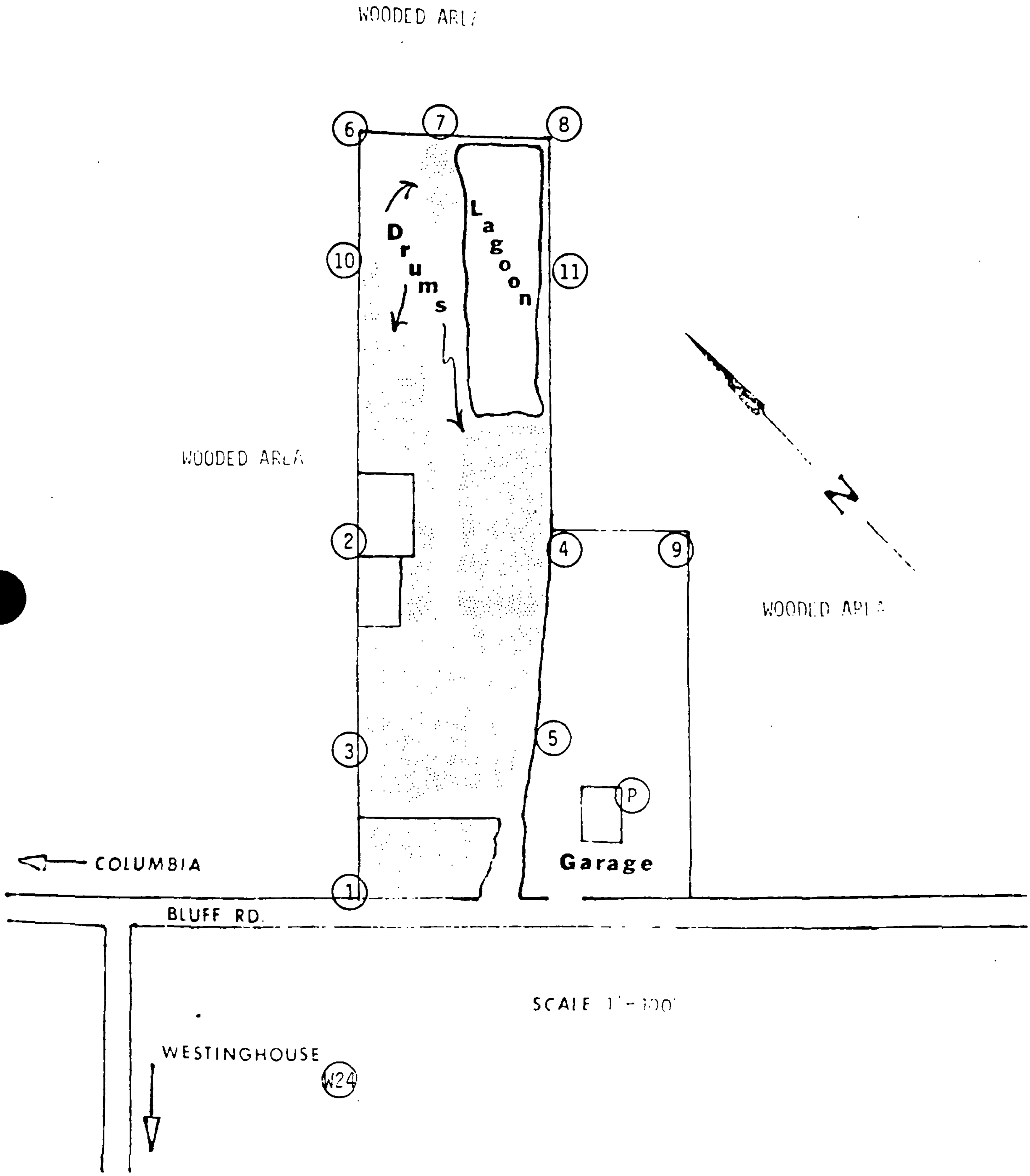



Figure 3. Map showing location of monitoring wells at S.C.R.& D. Bluff Road Site.

1 9 0058

DRILL HOLE LOG

Date: 6-12-80

County: Richland Grid Coord: Q29-f1 Lat-Long: 33°53'07" 80°[illegible]

Location: S.C. Recycling & Disposal, Inc. -Bluff Road B-1 left front corner along fence

Total Depth: 49'
Water Table: 14'
Screen Depth: 17-22'

Elevation:
Drilled by: Tom Champion & Raymond Knox
Logged by: Knox
Type Drill: Mobile B-34

*Sample taken corresponding to depth.

| Depth (ft) | Predom. Litho. | Grain Size (%) gravel | sand c | sand m | sand f | silt | clay | Angularity | Color | Comments (drilling characteristics, minerals, contacts, env. dep., etc.) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0–8 | sand | | | 10 | 70 | | 20 | | brown | 500 psi rot. (**)<br>7'-800 psi (**) |
| 8–10 | sand | | | 20 | 50 | | 30 | | lt. yellow-tan | slight increase in clay |
| 10–19 | sandy clay | 10 | 30 | 10 | | | 50 | | white to tan orange | some small ½-1" gravel<br>moisture increasing 13'-<br>[illegible] psi<br>very coarse sandy clay<br>saturated 15'<br>15'-430'psi |
| 19–47 | sand | | 10 | 50 | 10 | | 30 | | lt. tan | saturated-easy auger |
| | | | 10 | 70 | | | 20 | | | coarse angular sand<br>22' 450'psi<br>easy auger 29' 450 psi<br>no return 25-30' |
| | | | 10 | 80 | 0 | | 10 | | | easy auger 32' 430 psi<br>33' slightly bumpy, coarse angular sand on return<br>40' 450 psi<br>slightly bumpy 41-44'<br>43' 600 psi |
| | | | 5 | 80 | 10 | | 5 | | | 45' 700 psi, slightly harder to auger |
| 47–49 (TD) | tight clay | | | | 0 | 0 | 100 | | dark gray | 47' 450 psi<br>S.C. 100 umhos<br>Temp. 21°C<br>** Rotational psi |

Figure 4. Drill hole log Q29-f1.

1 9 0059

DRILL LOG B-2 — Date: 8-12-80

County: Richland — Grid Coord: Q29-f2 — Lat-Long: 33°53'27" 80°54'47"

Location: S.C. Recycling & Disposal, Inc. Bluff Road left rear

Total Depth: 34'
Water Table: 15'
Screen Depth: 9.5-14.5

Elevation: ________
Drilled by: Tom Champion & Raymond Knox
Logged by: Raymond Knox
Type of drill: Mobile B-34

*Sample taken corresponding to depth.

| Depth (m / ft) | Predom. Litho. | gravel | sand c | sand m | sand f | silt | clay | Angularity | Color | Loss | Comments (drilling characteristics, minerals, contacts, env. of dep., etc.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | sand | | | 10 | 70 | 10 | 10 | | brown | | dry-loose |
| 5 | sand | | | 20 | 60 | 10 | 10 | | yellow-tan | | 4' 700-800 psi tight sand |
| 10 | Clayey sand | | 10 | 10 | 30 | 10 | 40 | | tan-orange | | 8' 1000 psi slightly moist |
| | | | [illegible] | | | | 30 | | | | coarse sand & clay increasing with depth; moisture increasing with depth |
| 15, 20 | sandy w/ clay | | | | 70 | 10 | 20 | | lt. tan | | 15' 500 psi water table; easy auger 20-25' 400 psi |
| 25, 30 | sand w/ clay | | 0 | 0 | 70 | 10 | 20 | | lt. tan | | 27' 500 psi easy auger fine angular; 30'-400 psi |
| | sand w/ clay | | 20 | 20 | 30 | | 30 | | lt. tan | | easy auger coarser with depth |
| | | | 50 | 20 | 10 | | 20 | | | | |
| TD 35 | | | | | | | | | | | S.C. 95 umhos |
| | | | | | | | | | | | Temp. 22°C |

Figure 5. Drill hole log Q29-f2.

19 0060

DRILL HOLE LOG B-3

Date: 8-13-80

County: Richland  Grid Coord Q29-f3  Lat-Long: 33°53'07" 80°54'47"

Location: S.C. Recycling and Disposal - Bluff Road left side midways

Total Depth: 24'
Water Table: 14'
Screen Depth: 14-19'

Elevation:
Drilled by: Tom Champion & Raymond Knox
Logged by: Raymond Knox
Type Drill: Mobile B-34

*Sample taken corresponding to depth.

| Depth (ft) | Predom. Litho. | gravel | sand c | sand m | sand f | silt | clay | Angularity | Color | Foss | Comments (drilling characteristics, minerals, contacts, env. of dep., etc.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–10 | sand | | | 10 | 50 | 10 | 20 | | tan | | tight-dry<br>4' - 1000 psi<br>6' - 700 psi<br>7' - 950 psi<br>8' - very tight 1000 psi |
| | | | | 20 | 50 | 0 | 30 | | | | 9' - angular sand fairly clean, tight dry |
| 10– | | | 20 | 50 | 10 | | 20 | | orange tan to lt. tan | | 10' - 500 psi fairly easy to auger<br>11' - 750 psi<br>13' - 850 psi moisture increasing with depth |
| –25 | sand | | 30 | 60 | 0 | | 10 | | | | 14' - saturated<br>15' - 400 psi<br>15-20' - easy auger<br><br>Temp. 21°C<br>S.C. 80 umhos |
| TD 25 | | | | | | | | | | | |

Figure 6. Drill hole log Q29-f3.

1 9 0061

G29-f4

B-4 8-31-80

Campbell's Garage
left rear of lot

| | |
|---|---|
| 0-3.3' | lt. tan, fine sand |
| 3.3-3.8' | mottling, tan-white-orange, sand becoming coarser |
| 3.8-4.0' | fine sand with clay |
| 4.0-5.8' | lt. gray to white clayey fine sand |
| 5.8-7.5' | decreasing clay content, moist |
| 7.5-9.0' | saturated |
| 9.0-12.0' | chemical odor-coarse sand |
| 12.0' | Total Depth |

Temp. 22°C
S.C. 360 umhos
Screened 9'-12'

G29-f5

B-5

Campbell's Garage
midway to left rear

| | |
|---|---|
| 0-3.0' | fine brown sand |
| 3.0-6.6' | fine brown sand with increasing clay and some mottling |
| 6.6-8.0' | lt. tan clayey sand with gray mottling |
| 8.0-13.0' | fairly clean white to gray coarse-medium sand, saturated, chemical odor |
| 13.0' | Total Depth |

Temp. 22°C
S.C. 400 umhos
Screened 11'-13'

Figure 7. Drill hole logs G29-f4 and G29-f5.

1 9 0062

Q29-f6

B-6

left rear, away from lagoon

| | |
|---|---|
| 0-2.0' | fine lt. gray to tan sand with clay grades to lt. tan |
| 2.0-3.5' | orange and gray mottling slight increase in grain size-tight with more clay |
| 3.5-6.3' | lt. orange and white medium sand with clay-loose grading to orange orange medium sand little clay |
| 6.3-6.6' | orange medium sand with trace clay |
| 6.6-7.0' | grain size increase with depth, moist |
| 7.0-10.3' | saturated |
| 10.3-12.0' | gray coarse sand with gravel (qtz.) |
| 12.0' | Total Depth |

Screened 9.5'-12.0'

Q29-f7

B-7

center rear

| | |
|---|---|
| 0-1' | lt. gray to lt. tan tight fine sand |
| 1' | lt. gray clayey fine sand with orange mottling |
| 1-3.5' | orange medium sand with gray mottling (clayey) |
| 3.5-4.0' | gray clayey fine sand with orange mottling |
| 4.0-5.3' | clean loose white to lt. tan medium sand with trace coarse sand and trace clay |
| 5.3-5.6' | clean loose orange medium sand grading to a lt. tan to gray medium sand |
| 5.6-9.0' | lt. gray moist medium sand with trace of clay, moist at 8.0' |
| 9.5-12.0 | saturated-lt. gray medium to coarse sand-trace of clay |
| 12.0' | Total Depth |

Screened 9.5'-12.0'

Figure 8. Drill hole logs Q29-f6 and Q29-f7.

Q29-f8
5-8 8-14-80
right rear, off lagoon

| | |
|---|---|
| -2.0' | fine gray to tan fine sand with natural organic material and trace of clay, grading to lt. tan-white |
| .0-2.5' | tight-fine lt. tan-white sand mottled orange, trace of clay |
| 2.5-3.8' | clay increasing with depth, mottled gray and orange fine clayey sand |
| 3.8-6.0' | lt. orange to gray-tan medium sand decreasing clay content, some mottling |
| 6.0-6.6' | orange medium sand clay content decreasing |
| 6.6-12.0' | gray coarse sand slightly moist with small isolated clay lenses |
| 12.0' | Total Depth |

Saturated at 10.83'
Screened 9.5'-12.0'

Q29-f9
5-9 8-19-80
Campbell's Garage
right rear

| | |
|---|---|
| -2.0' | lt. gray to tan fine silty sand |
| .0-3.0' | lt. tan fine silty sand-mottled orange |
| 3.0-4.0' | lt. tan to gray fine sand with clay, tight |
| 4.0-4.6 | gray to tan medium sand with clay (orange mottling) |
| 4.6-9.6 | gray medium to coarse sand with trace clay (orange mottling easier to auger |
| 9.6-12.0' | saturated-gray medium to coarse sand with trace of clay-some gravels |
| 12.0' | lt. gray-tan clay -- Total Depth |

Screened 9.4'-12.0'

Figure 9. Drill hole [illegible]

Q29-f10

B-10 8-20-80

left rear on side near #6

| | |
|---|---|
| 0-4.0' | mottled orange clayey fine sand |
| 4.0-5.6' | orange mottled gray medium sand with some clay |
| 5.6-7.75' | lt. tan to lt. gray medium sand with some clay |
| 7.75-8.5' | lt. gray micaceous medium to fine clayey sand |
| 8.5-9.6' | tan clayey medium sand |
| 9.6' | saturated |
| 9.6-15.0' | white medium coarse sand some clay |
| 15.0' | Total Depth |

Screened 12.0'-15.0'

Q29-f11

B-11 8-26-80

| | |
|---|---|
| 0-2.25' | gray fine sand mottled orange with organic material |
| 2.25-3.0 | gray sandy clay mottled orange (very tight) |
| 3.0-3.5' | sand content increasing |
| 3.5-5.0' | orange and gray fine sand with clay (still very tight) |
| 5.0-7.25' | orange to lt. tan-gray medium sand with clay |
| 7.25-12.0' | graded into a light gray to light tan sand (medium to coarse with gravels) moist, saturated at 8.91' |
| 12.0' | Total Depth |

Screened 9.5'-12.0'

Figure 10. Drill hole logs Q29-f10 and Q29-f11.

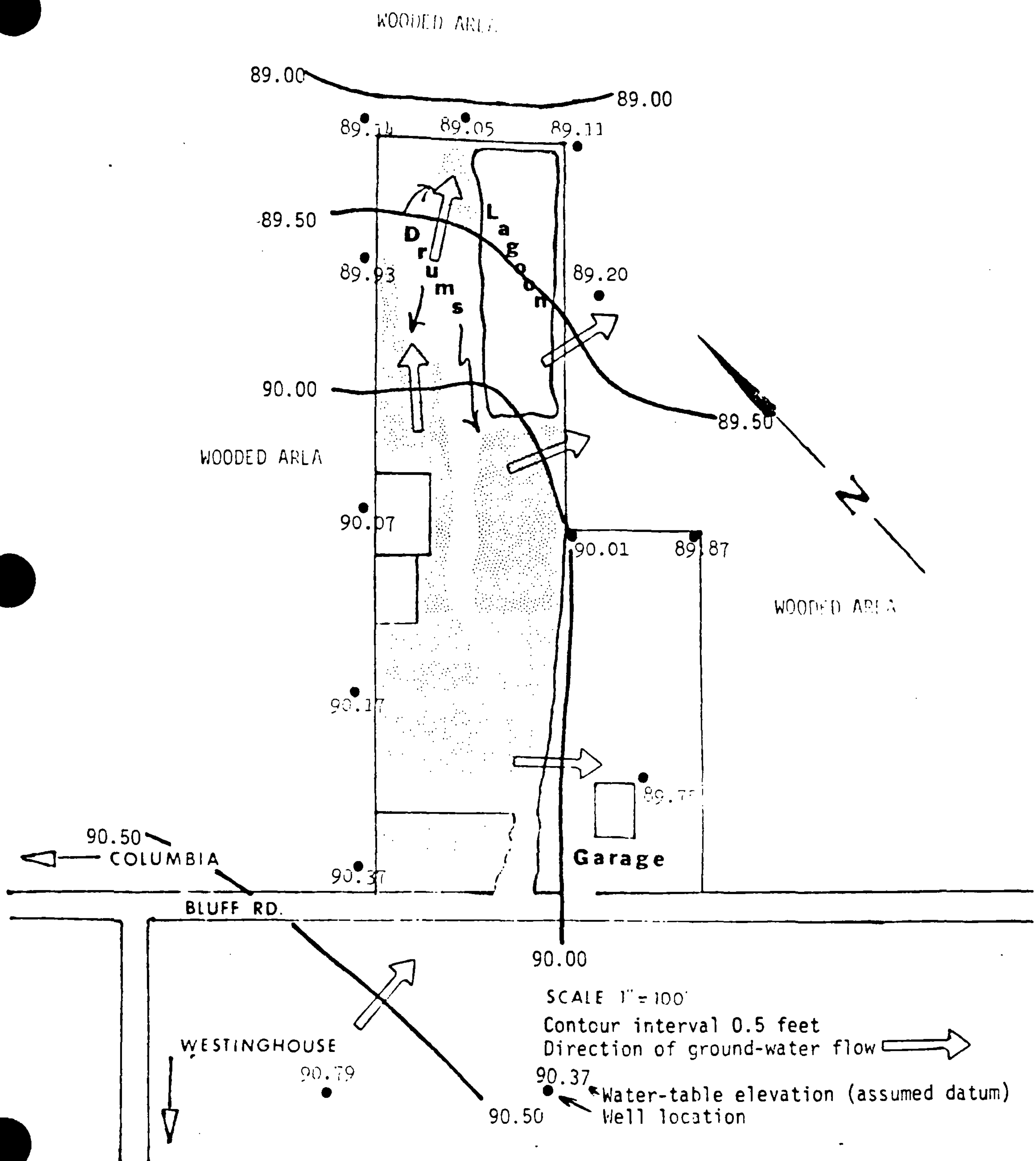



Figure 13. Map showing contours on potentiometric surface at S.C.R.& D. Bluff Road Site 9-4-80.

1 9 0066

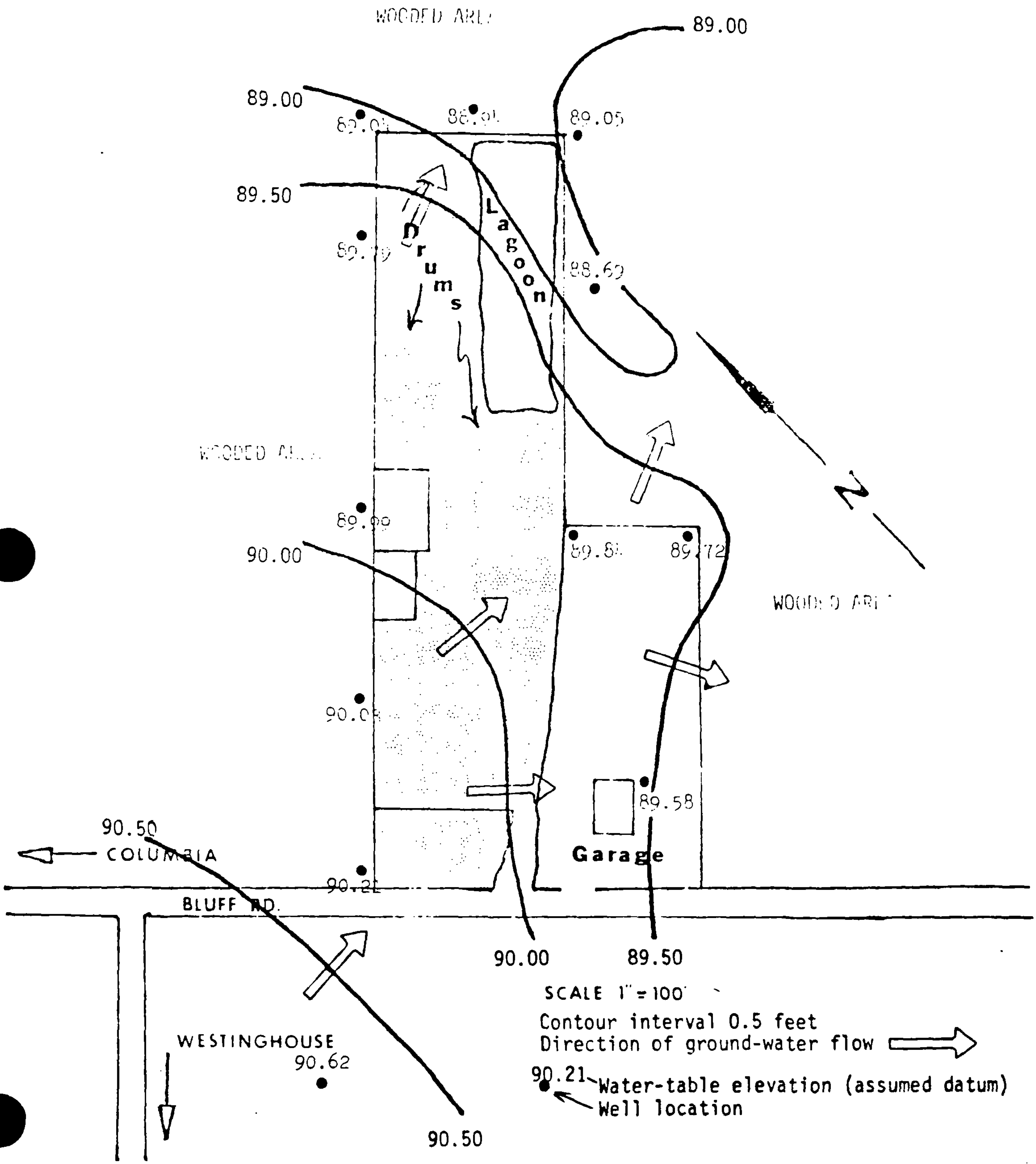



Figure 14. Map showing contours on potentiometric surface at S.C.R.& D. Bluff Road Site 9-9-80.

1 9 0067

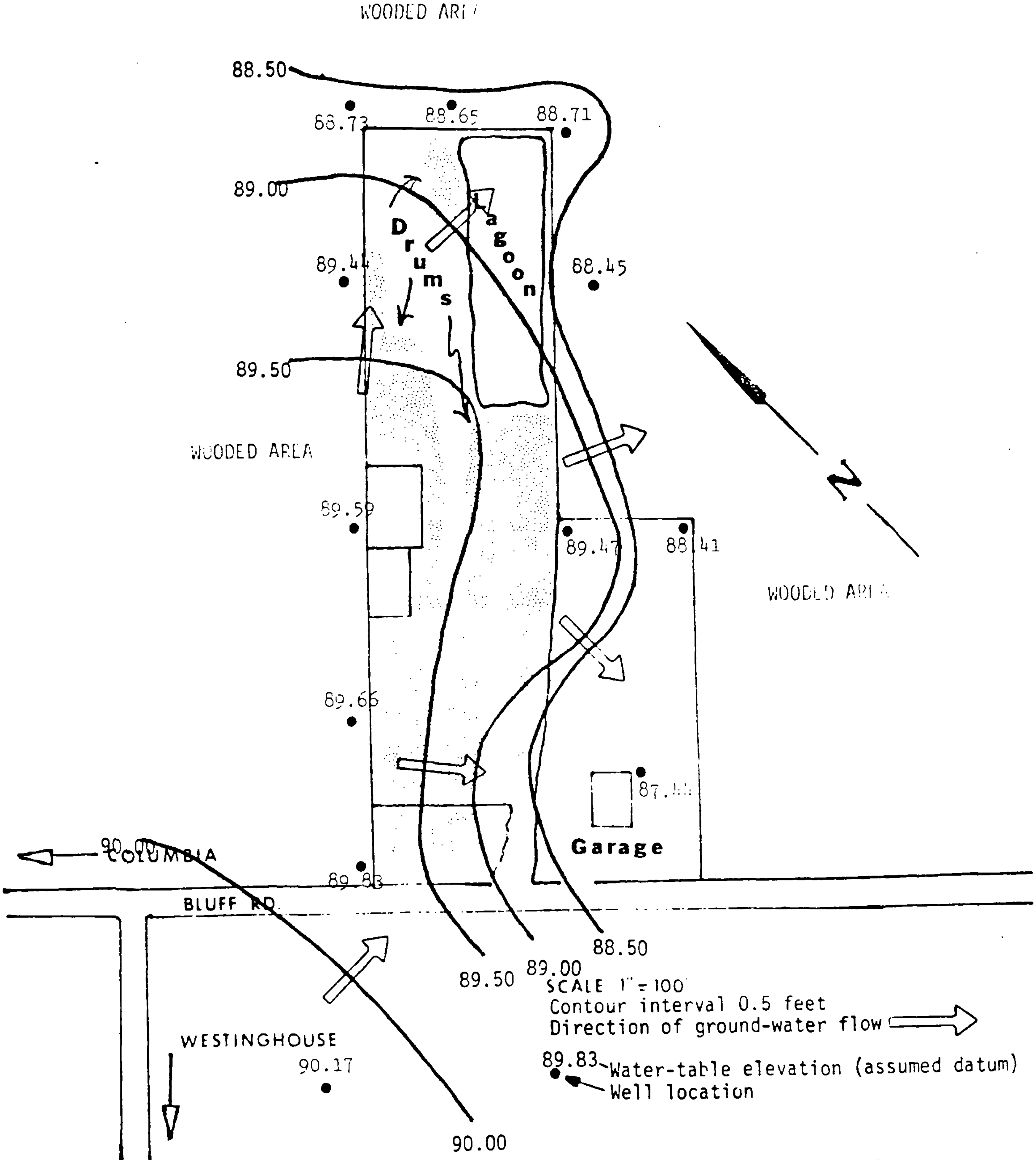



Figure 15. Map showing contours on potentiometric surface at S.C.R.& D. Bluff Road Site 9-22-80.

1 9 0068

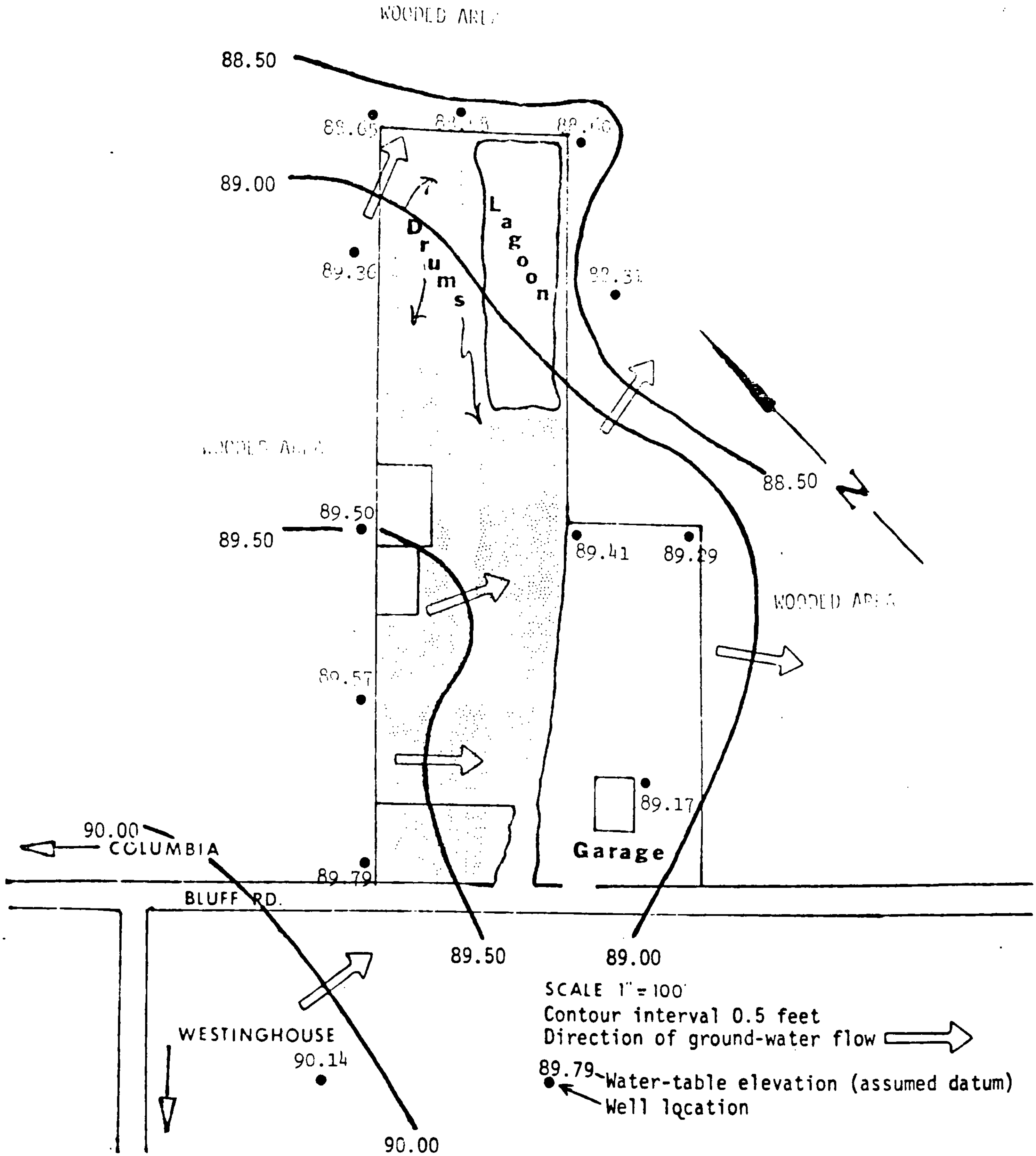



Figure 16. Map showing contours on potentiometric surface at S.C.R.& D. Bluff Road Site 9-25-80.

1 9 0069

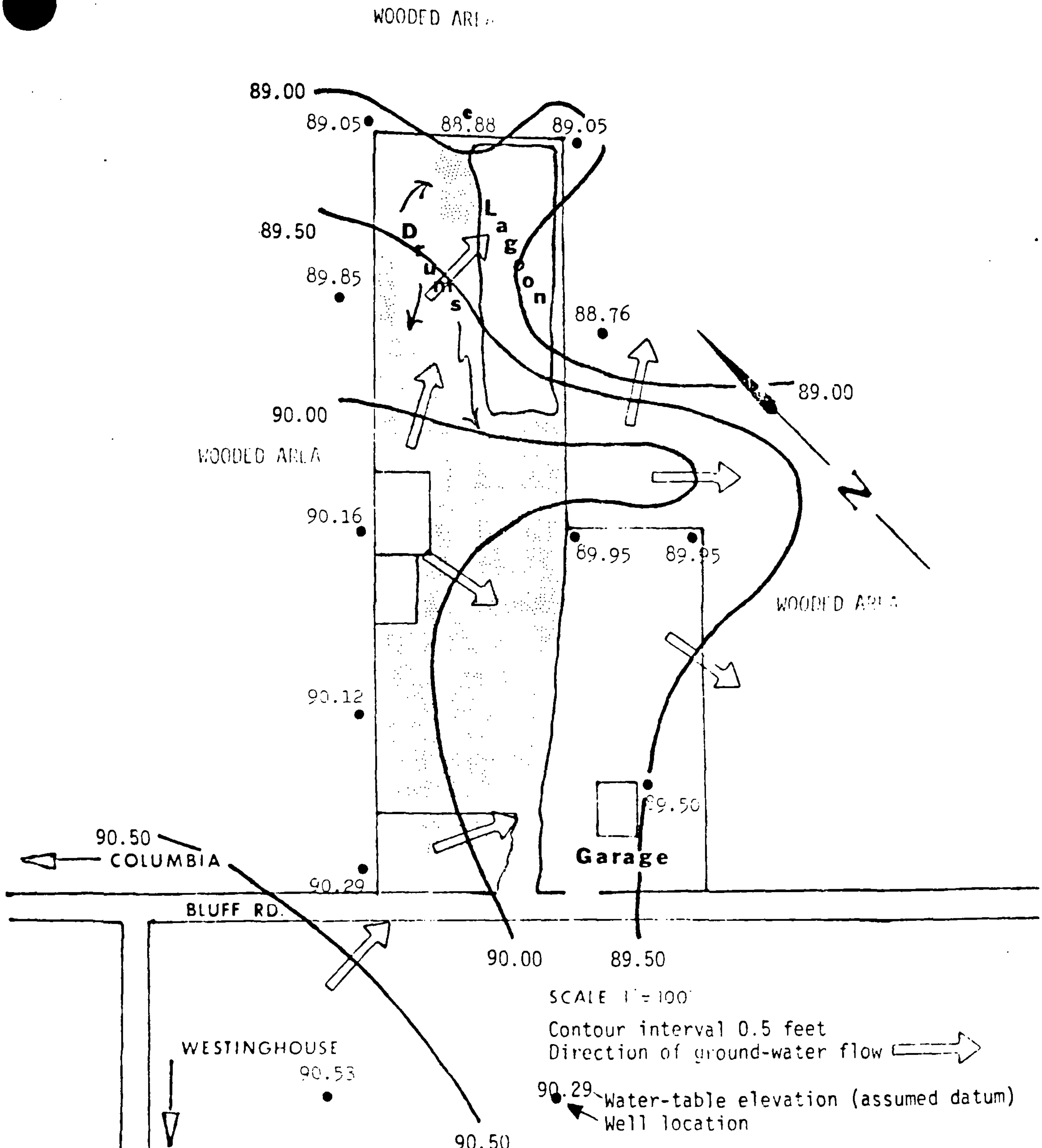



Figure 17. Map showing contours on potentiometric surface at S.C.R.& D. Bluff Road Site 10-3-80.

Table 4

**Water Table** Elevations at S.C.R. & D. Bluff Road Site

| Date | Well No. 1 | Well No. 2 | Well No. 3 | Well No. 4 | Well No. 6 | Well No. 7 | Well No. 8 | Well No. 9 | Well No. 10 | Well No. 11 | Garage Well | W-24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9-4-80 | 90.37 | 90.07 | 90.17 | 90.01 | 89.14 | 89.05 | 89.11 | 89.87 | [illegible] | [illegible] | 89.75 | 90.79 |
| 9-9-80 | 90.21 | 89.99 | 90.03 | 89.84 | 89.04 | 88.94 | 89.05 | 89.72 | 89.79 | 88.69 | 89.58 | 90.62 |
| 9-22-80 | 89.83 | 89.59 | 89.66 | 89.49 | 88.73 | 88.65 | 88.71 | 88.41 | 89.44 | 88.45 | 87.44 | 90.17 |
| 9-25-80 | 89.79 | 89.50 | 89.57 | 89.41 | 88.65 | 88.58 | 88.58 | [illegible] | [illegible] | 88.31 | 89.17 | 90.14 |
| 10-3-80 | 90.29 | 90.16 | 90.12 | 89.95 | 89.05 | 88.88 | 89.05 | 89.95 | 89.85 | 88.76 | 89.50 | 90.53 |

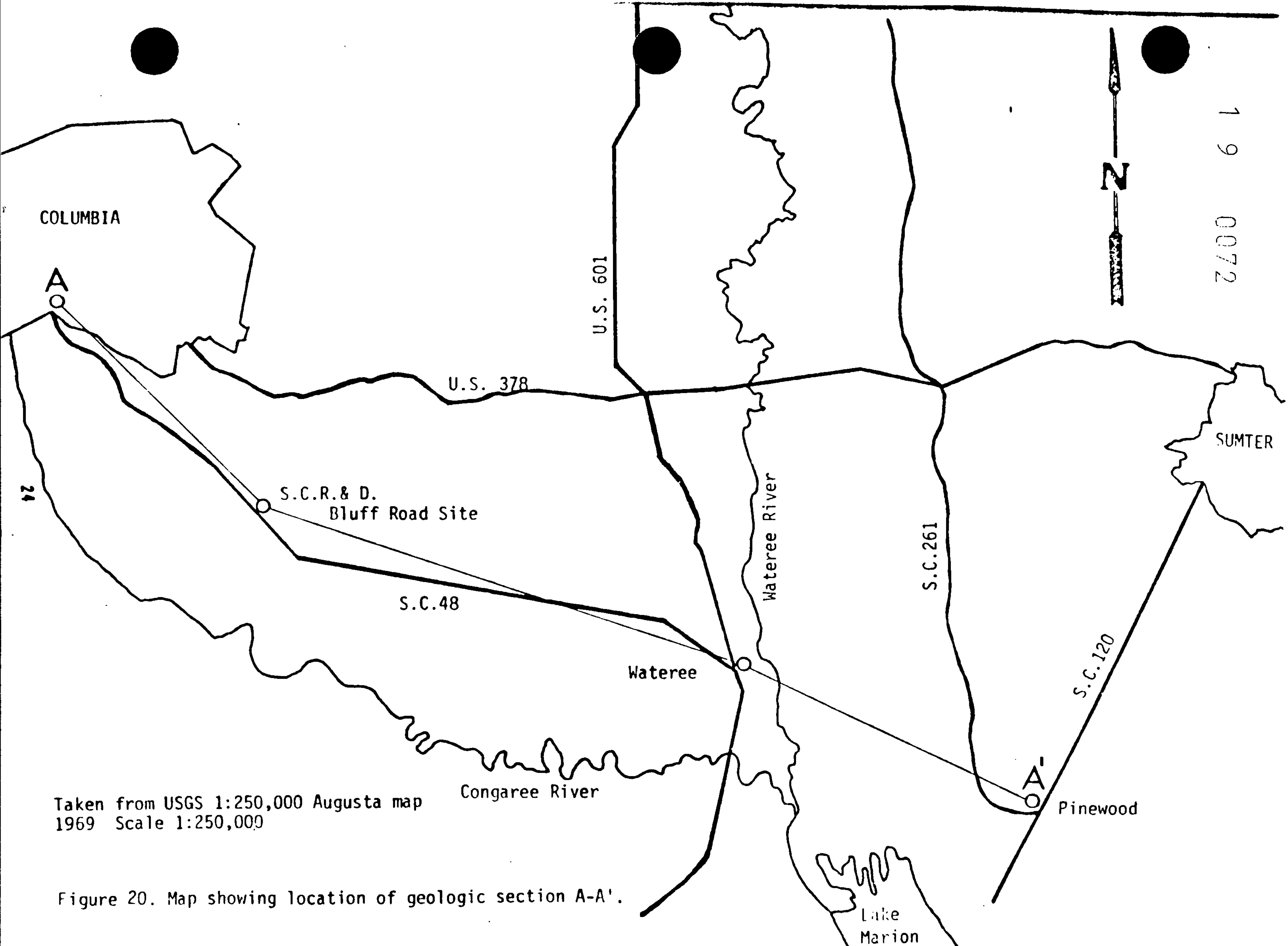
HYDROGEOLOGY

There are three geologic formations which may be considered aquifer systems beneath the S.C.R.& D. Bluff Road site (fig. 21). They are in descending order; undifferentiated Pliocene-Pleistocene sediments, the Black Mingo Formation, and the Middendorf Formation. The Black Creek Formation may be present between the Black Mingo Formation and the Middendorf Formation, however, lack of deep well data from the immediate area makes it impossible to determine its presence or absence.

The Pliocene-Pleistocene shallow sediments typically consist of light-tan, brown, orange, white to gray fine to coarse sands and gravels in a slightly clayey matrix with occasional isolated light-grey to tan clay lenses. Water quality is generally good with low concentrations of total dissolved solids and a pH between 5 and 6. This surficial aquifer in most localities is very susceptible to contamination from spills and improper waste disposal practices.

The Pliocene-Pleistocene sediments beneath the site consist of slightly clayey to clayey, medium to very coarse, angular quartz and feldspathic sands to a depth of forty-five feet (13.5 m). This site is located on a mappable feature occurring at an elevation of 140 to 150 feet (mean sea level) named the Okefenokee Terrace (Cooke, 1936, 1954). The Okefenokee Terrace lies within the present-day Congaree River Valley (Colquhoun, 1965).

The Pliocene-Pleistocene sediments make up the surficial aquifer for the area. Local domestic wells, such as the well at Campbell's Garage immediately to the southeast, are commonly less than 50 feet (15 m) deep, and usually yield 10 to 15 gallons per minute (gpm).




Taken from USGS 1:250,000 Augusta map
1969 Scale 1:250,000

Figure 20. Map showing location of geologic section A-A'.

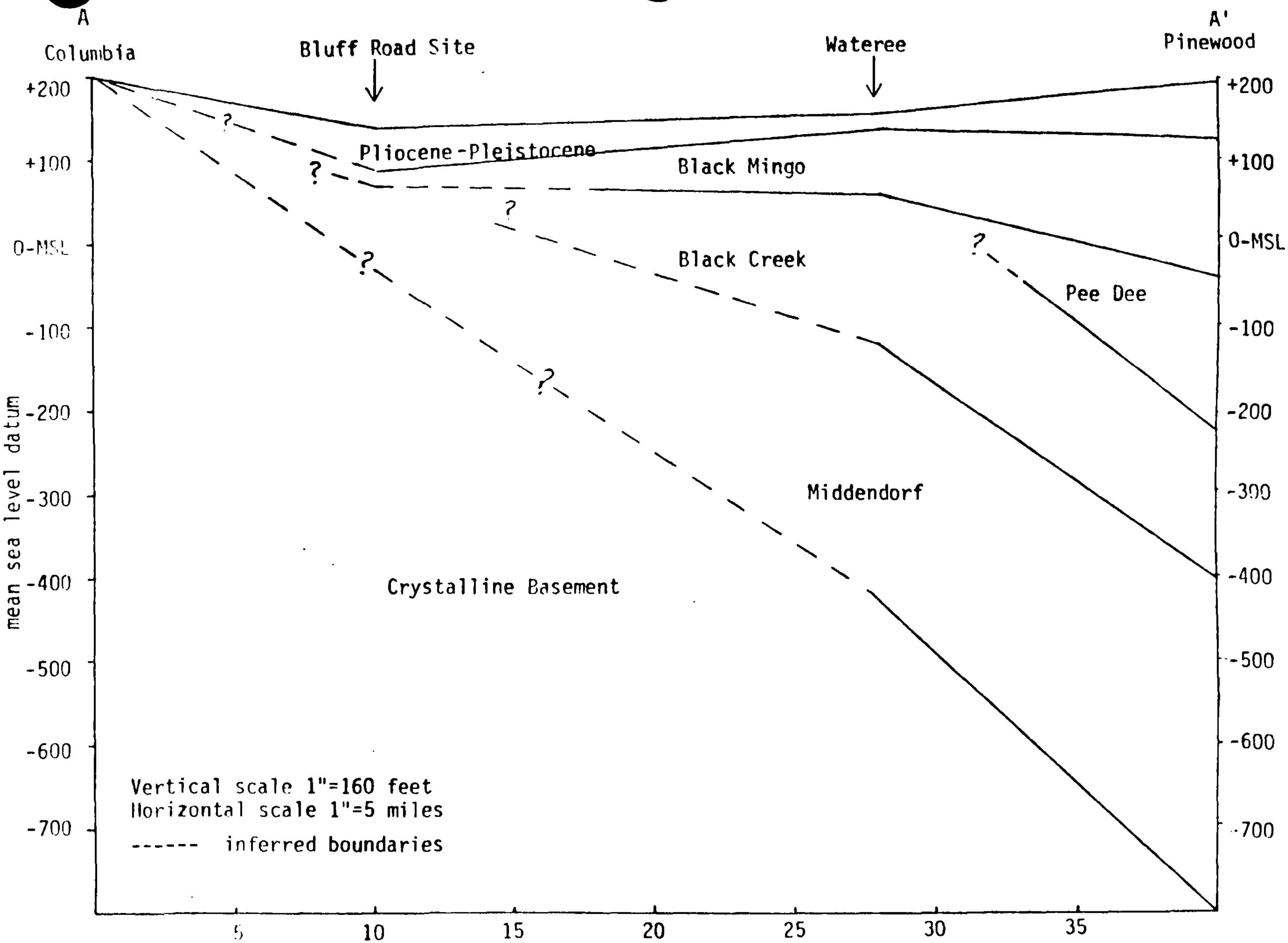



Figure 21. Generalized geologic section A-A' from Columbia to Pinewood.

Water-level measurements indicate a very slight hydraulic gradient (about 0.2%) across the site within the surficial aquifer. Because of this very slight gradient, small changes in water levels caused by differential recharge rates may result in changes in ground-water flow direction (figure 13 through 17). Flow direction may also be locally influenced by pumping of the garage well. Based on an assumed hydraulic conductivity range of $1 \times 10^{-3}$ to $1 \times 10^{-2}$ cm/sec for silty sands and a gradient of 0.2%, the average range of ground-water velocity would be 0.006 to 0.06 feet/day (0.63 to 6.3 meters/ year). This is a theoretical range of values, and may vary across the site due to differences in permeability.

Precipitation was relatively low during the period of investigation. The water table dropped about 0.5 feet between August 12 and October 3. 1980. Shortly after the field investigation ended, rainfall caused a slight increase in water-table elevation (fig. 18 and 19).

Beneath the Pliocene-Pleistocene sediments is the Black Mingo Formation of Eocene Age. Padgett (1980) concluded that the Black Mingo Formation consists of three members; the Williamsburg, Upper Deltaic sequence, and the Rhems member (listed in descending order).

Padgett (1980) described the Williamsburg member as a sequence of dark siliceous clays, fuller's earth, and fine-to-medium grained sands representative of marsh and intertidal depositional environments. Padgett further described an erosional unconformity separating the dark clays and intertidal sands of the Williamsburg member from the underlying poorly-sorted, coarse, micaeous, feldspathic sands and massive blue-gray sandy kaolinitic clays of alluvial to marginal marine depositional origin. The dark clays and associated opaline claystones and fuller's

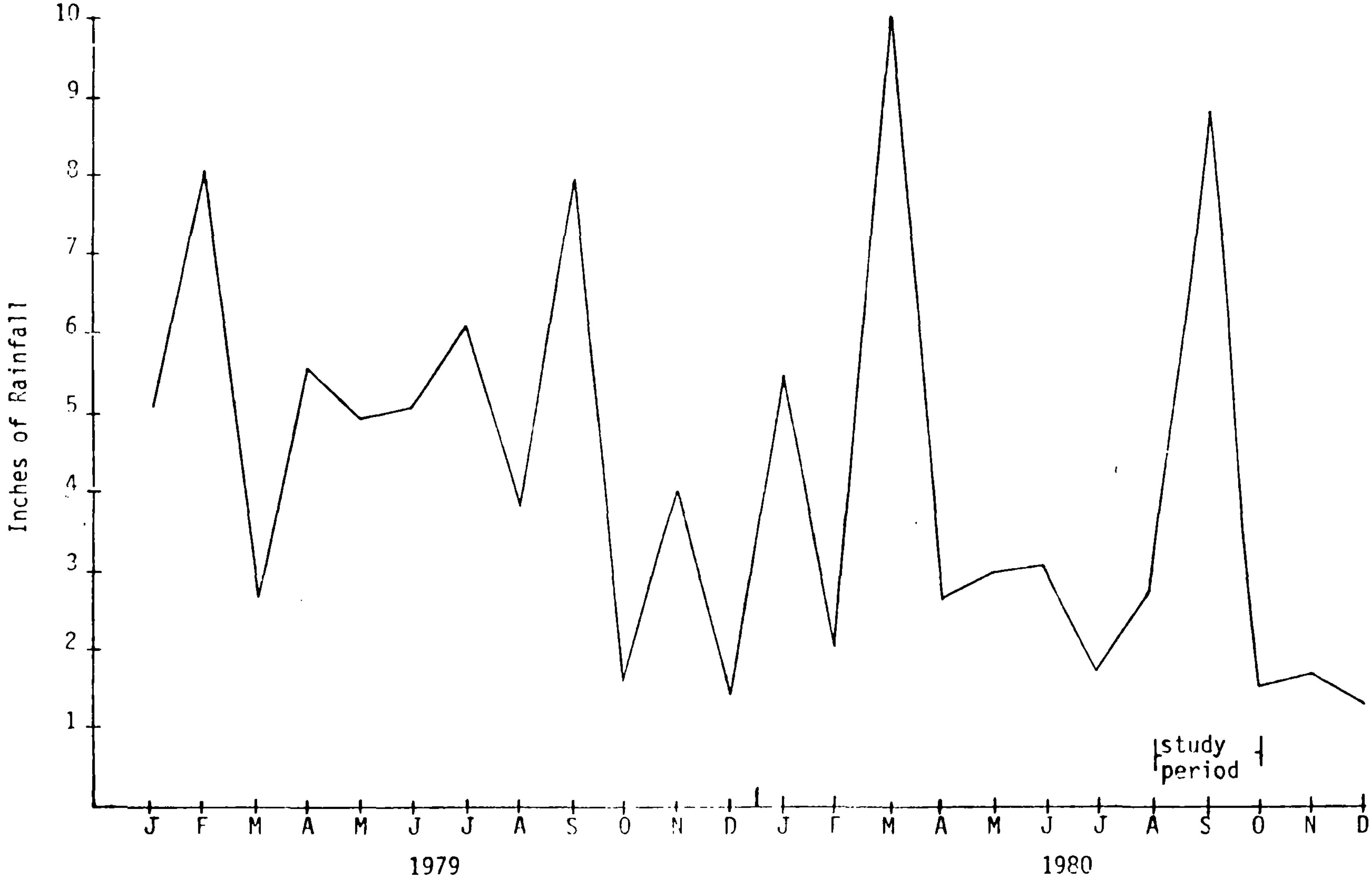



Figure 18. Monthly precipitation record from University of South Carolina, Columbia.

1 9 0076

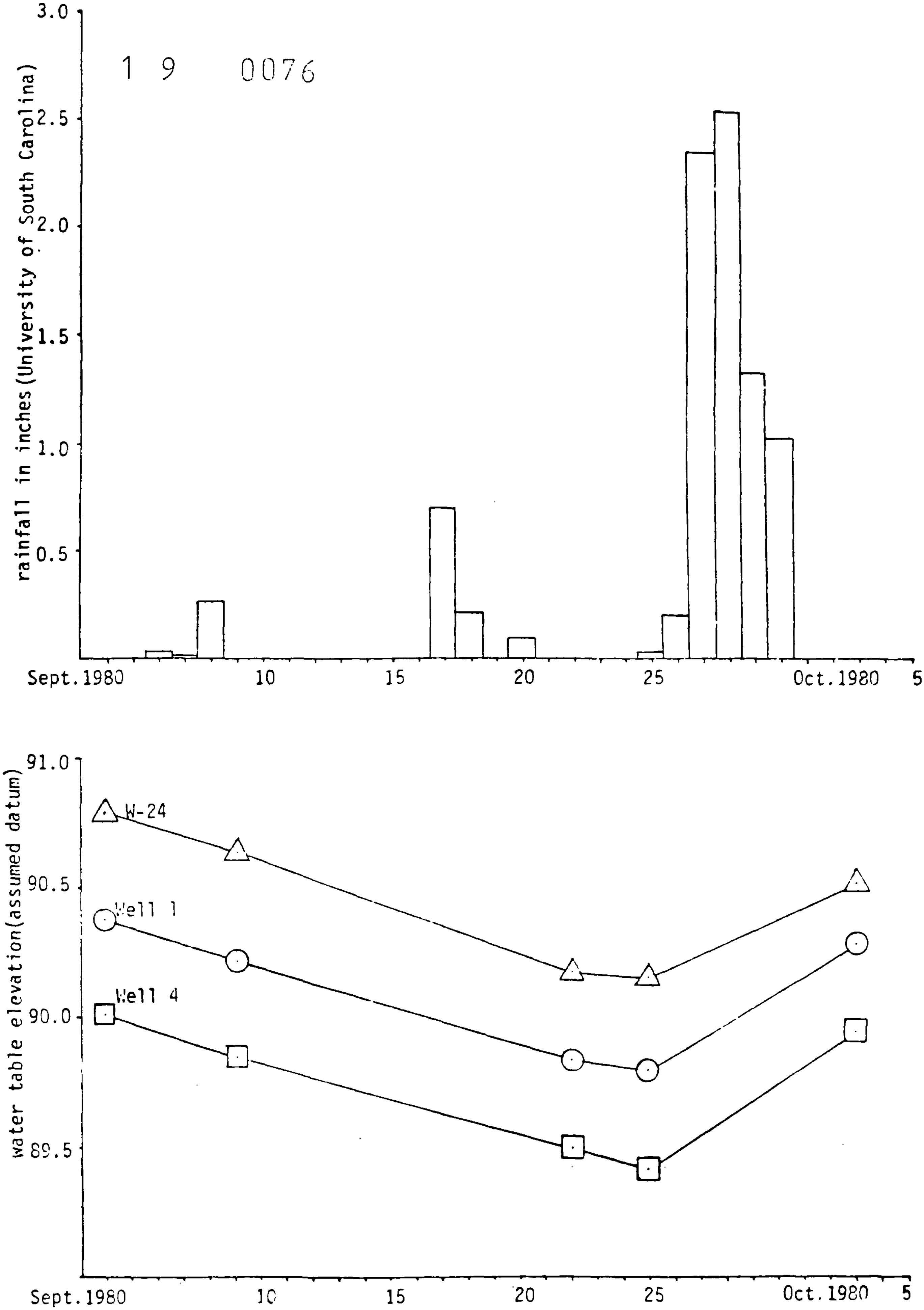



Figure 19. Changes in water levels at S.C.R.& D. Bluff Road site compared with rainfall.

earth are confining beds. The fuller's earth section of the Black Mingo Formation is utilized as a geologic backup for a hazardous-waste disposal facility at Pinewood, South Carolina, in Sumter County. In areas where the confining clays are absent, a strong potential for contamination exists. The Black Mingo Formation is estimated to be 75 feet (23 m) thick at the Bluff Road site. No nearby deep well control is available to ascertain its exact thickness at that point.

The sands within the Black Mingo Formation are aquifers, providing yields of 20 to 50 gpm, suitable for light industry and domestic use. The water usually has a pH of 7.2 to 7.5, with moderate concentrations (80-120 mg/l) of dissolved solids. Localized problems with sulfate and iron may occur.

The Black Creek Formation is probably absent at the Bluff Road site. The unit appears to pinch out between Godspeed Farms at Wateree, South Carolina, and the Bluff Road site. The Black Creek Formation typically consists of very dark gray to black laminated clays and white to tan micaeous sands which are somewhat phosphatic and glauconitic (Siple, 1957). The sands are major aquifers over a large part of the Middle and Lower Coastal Plain. The water is generally of good quality, pH about 8.0, with some high fluoride levels in the immediate coastal areas. Well yields vary from 50 gpm in the thinner sections to more than 750 gpm in thicker sections. No data are available to determine the water bearing characteristics of the Black Creek Formation.

The Middendorf Formation of Cretaceous Age normally consists of gravel, cross-bedded, kaolinitic sands and gravels with lenticular kaolin bodies. The presence of the Middendorf Formation beneath the Black Mingo Formation (and Black Creek Formation, if present) is inferred.

The thickness of the Middendorf Formation beneath the site is unknown due to lack of data.

Water from the Middendorf Formation is generally soft and low in total dissolved solids. Wells may yield more than 1,000 gpm in thicker sections seaward. Wells developed in the Middendorf Formation in the area of the Bluff Road site would not yield this much due to the thinness of the section.

The sedimentary formations discussed above are underlain by Piedmont type igneous and low and high grade metamorphic rocks. The basement rocks commonly have a weathered zone known as saprolite which grades down to unweathered rock. Ground water occurs in fractures or joints within the rocks. Water quality and well yields may vary greatly over short vertical and horizontal distances. No site specific data on the hydrogeologic characteristics of the basement rocks are available.

## GROUND-WATER QUALITY IN THE SURFICIAL AQUIFER

Specific conductance ranges from a background level of 35 micromhos per centimeter (umhos/cm) to a high of 600 micromhos per centimeter (umhos/ cm). The conductivity is highest in downgradient wells 4, 5, 6, and 7. These relatively high values are indicative of elevated amounts of dissolved materials in the ground water. This is supported by the analyses for total dissolved solids which ranged from 40 mg/l to 530 mg/l.

Chloride was used as an indicator of contamination because it is easily analyzed for, very soluble, highly mobile in soil and ground water, and background chloride concentration in uncontaminated shallow aquifers of the Upper Coastal Plain sediments is very low (a few milligrams per liter). Increased chloride concentrations occur down hydraulic

 Table 1. Well Construction Data and Specific Conductance.

S.C. RECYCLING AND DISPOSAL

BLUFF ROAD SITE

| Well Number | Date Drilled | Total Depth | Screened Interval | Specific Conductance | Date |
|---|---|---|---|---|---|
| 1 | 8-12-80 | 49' | 17'-22' | 100 umhos | 8-12-80 |
| | | | | 60 | 8-19-80 |
| | | | | 100 | 8-27-80 |
| | | | | 90 | 9-25-80 |
| | | | | 80 (top) | 10-03-80 |
| | | | | 130 (bottom) | |
| 2 | 8-12-80 | 34' | 9.5'-14.5' | 95 umhos | 8-12-80 |
| | | | | 50 umhos | 8-27-80 |
| | | | | 30 umhos | 9-25-80 |
| | | | | 40 umhos (top) | 10-03-80 |
| | | | | 55 umhos (bottom) | |
| 3 | 8-13-80 | 24' | 14'-19' | 80 umhos | 8-13-80 |
| | | | | 30 umhos | 8-19-80 |
| | | | | 70 umhos | 8-27-80 |
| | | | | 70 umhos | 9-25-80 |
| | | | | 60 umhos (top) | 10-03-80 |
| | | | | 80 umhos (bottom) | |
| 4 | 8-13-80 | 12' | 9'-12' | 360 umhos | 8-13-80 |
| | | | | 300 umhos | 8-27-80 |
| | | | | 600 umhos | 9-25-80 |
| | | | | 480 umhos (top) | 10-03-80 |
| | | | | 460 umhos (bottom) | |
| 5* | 8-13-80 | 13' | 11'-13' | 400 umhos | 8-13-80 |
| 6 | 8-14-80 | 12' | 9.5'-12' | 280 umhos | 8-20-80 |
| | | | | 380 umhos | 8-27-80 |
| | | | | 155 umhos | 9-25-80 |
| | | | | 100 umhos (top) | 10-03-80 |
| | | | | 1,500 umhos (bottom) | |
| 7 | 8-14-80 | 12' | 9.5'-12' | 290 umhos | 8-20-80 |
| | | | | 300 umhos | 8-27-80 |
| | | | | 265 umhos | 9-25-80 |
| | | | | 270 umhos (top) | 10-3-80 |
| | | | | 600 umhos (bottom) | |
| 8 | 8-14-80 | 12' | 9.5'-12' | 95 umhos | 8-27-80 |
| | | | | 90 umhos | 9-25-80 |
| | | | | 90 umhos (top) | 10-03-80 |
| | | | | 110 umhos (bottom) | |
| 9 | 8-19-80 | 12' | 9.5'-12' | 35 umhos | 9-25-80 |
| | | | | 50 umhos (top) | 10-03-80 |
| | | | | 60 umhos (bottom) | |
| 10 | 8-20-80 | 15' | 12'-15' | 70 umhos | 8-20-80 |
| | | | | 20 umhos | 8-27-80 |
| | | | | 40 umhos | 9-25-80 |
| | | | | 40 umhos | 10-03-80 |
| 11 | 8-26-80 | 12' | 9.5'-12.0' | 100 umhos | 8-27-80 |
| | | | | 120 umhos | 9-25-80 |
| | | | | 115 umhos (top) | 10-03-80 |
| | | | | 125 umhos (bottom) | |
| W-24 | 7-09-80 | 16' | 11'-16' | 60 umhos | 9-25-80 |
| | | | | 60 umhos | 10-03-80 |
| Campbell's Garage Well | unknown | unknown | unknown | 30 umhos | 8-27-80 |
| | | | | 35 umhos | 9-25-80 |

* Destroyed
Note: Well 4-11 were constructed by hand

gradient, in the direction of ground-water flow. Results of chloride analyses are plotted in figure 11.

Lead exceeded the drinking-water standard (0.05 mg/l) in wells 2, 6, 7, 8, 9, 11, and W-24. Highest levels of lead occurred in well W-24 (0.14 mg/l).

Ground-water contamination from volatile organics appears to be widespread. All wells sampled contained one or more volatile organic substances. (table 3 and fig. 12). All of the wells contained at least one of several volatile organic substances found in samples collected from spills (see table 3). An additional compound, tetrahydrofuran, occurring in wells 1, 6 through 11, and W24, was found in runoff from a ditch in front of the site by the USEPA in July, 1980.

Iron concentrations are generally elevated in the area. The concentrations range from 20 mg/l in well W-24, to 0.1 mg/l in wells 1 and 3. The change in pH brought on by the presence of contaminants has possibly upset the natural iron stability, causing the increased iron concentrations.

The movement of non-polar organic compounds in ground water is not yet fully understood. In light of relatively stagnant ground-water, diffusion and capillary action may be a significant driving force for movement of contaminants in directions other than in the predominant direction of ground-water flow. This may account for the widespread occurrence, even up-gradient, of some organic compounds. This may also explain the presence of lead in W-24.

The flashpoint of the samples ranged from greater than 170 degrees Fahrenheit (°F) to 155 °F and confirmed the presence of significant amounts of the volatile organics identified in laboratory analyses.

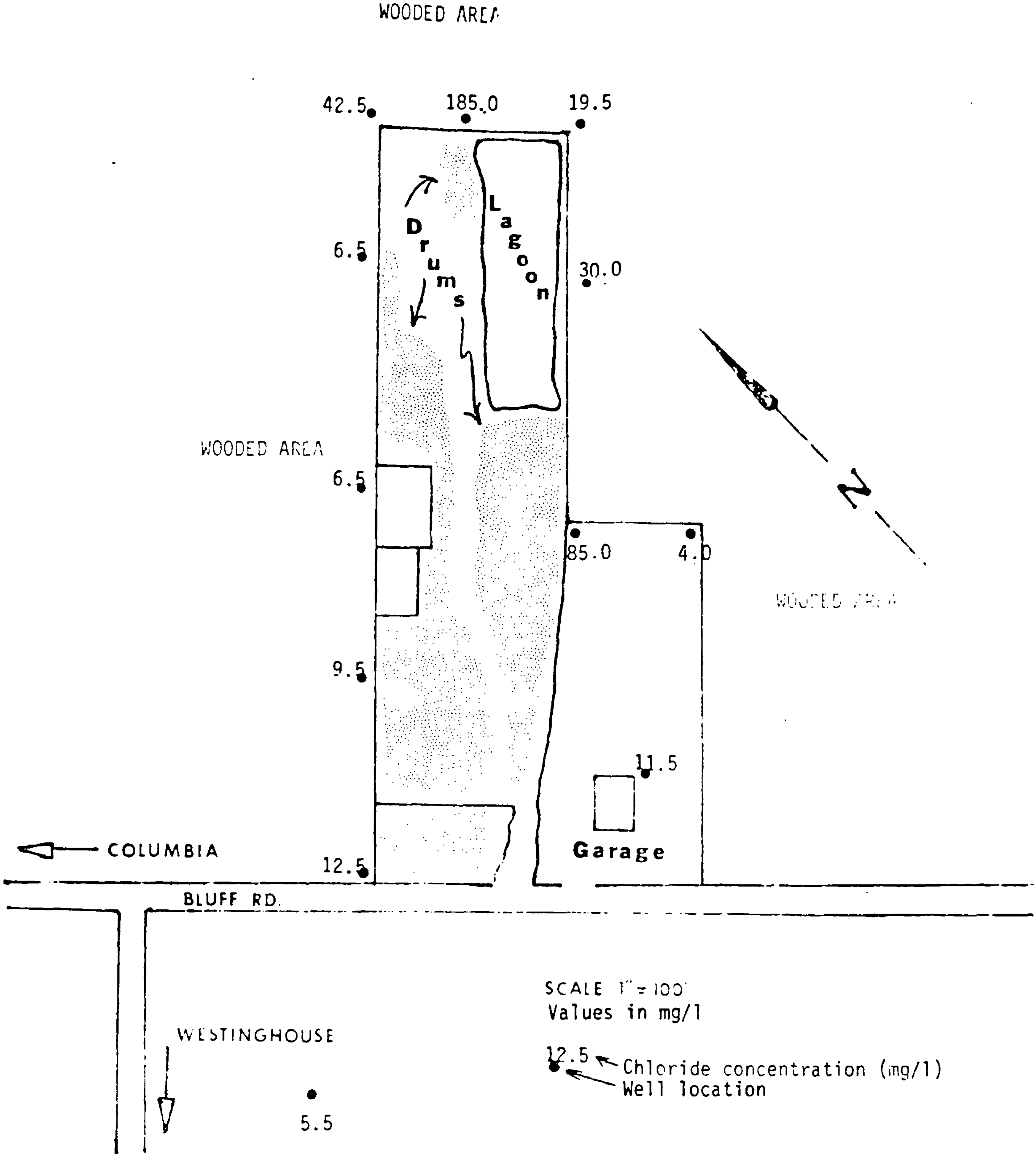



Figure 11. Map showing chloride distribution at S.C.R.& D.
Bluff Road site.

1 9 0082

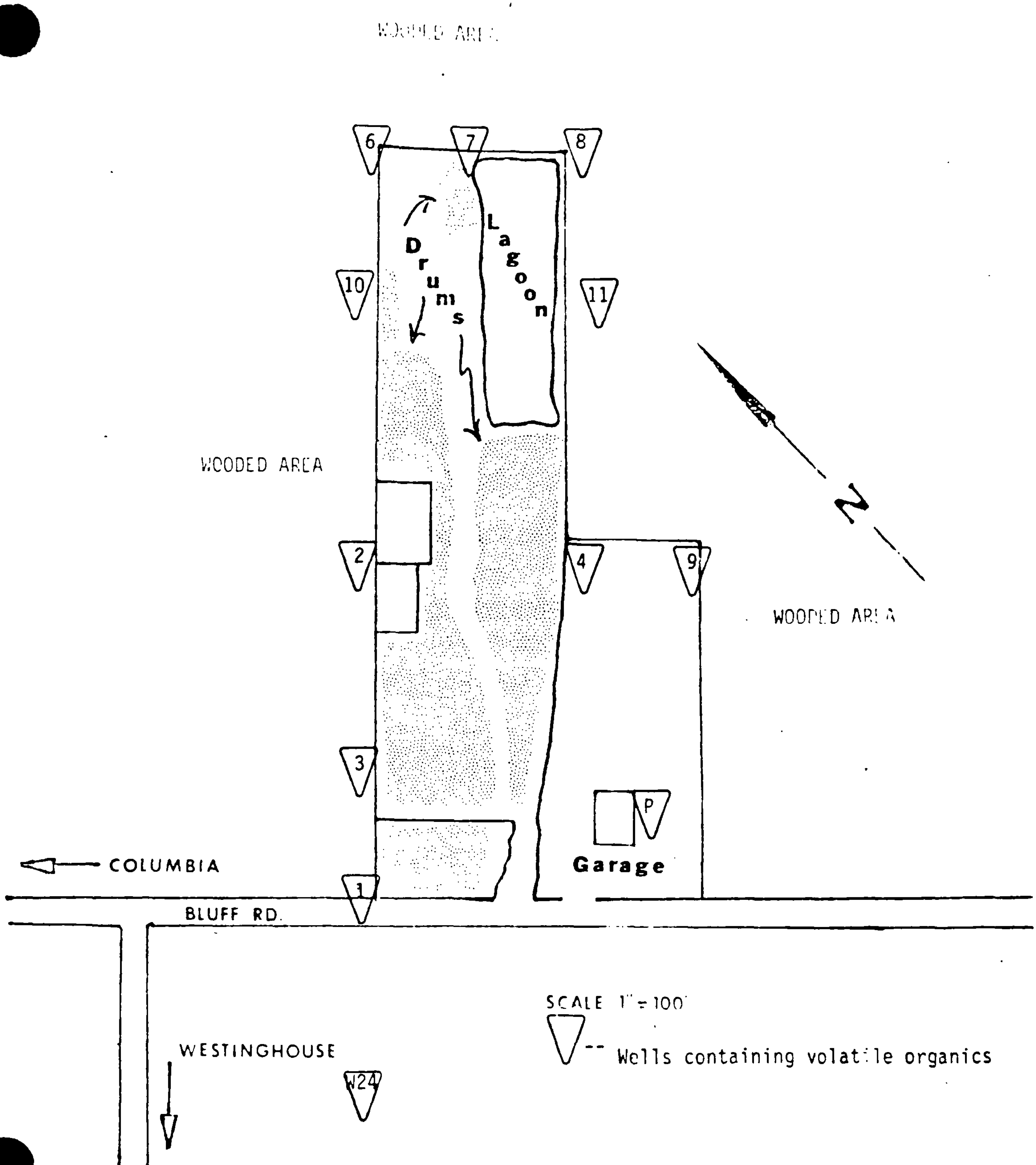



Figure 12. Map showing wells containing volatile organics at the S.C.R.& D. Bluff Road Site.

1 9 0083

Table 3. Volatile Organics Analyses at S.C.R.&D. Bluff Road Site. Results in mg/l unless noted

| VOLATILE ORGANICS | Well Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 6 | 7 | 8 | 9 | 10 | 11 |
| Tetrahydrofuran | x | | | | x | x | x | x | x | x |
| 1,1,1-Trichlorethane | | x | x | | | 15** | | | | |
| Tetrachlorethene | | | | x | | x | | | | |
| Toluene | | | | | x | | 13** | 12** | | |
| Trichloroflurومethane | x | | | 0.11 | | | | | | |
| Trichloromethane | | | x | x | | x | | | | |
| 1,1-dichloro-1-nitro-ethane | | | | x | | | | | x | |
| Trichloroethane | | x | | x | | | | | | |
| Methyl benzene | | | | .54 | | x | | | | |
| Ethyl benzene | | | | .28 | | | trace | | | |
| 2-butanone | | | | | | x | | x | | |
| 2-methyl-1-pentene | | | | | | | | | | |
| Thiobismethane | | | | x | | | | | | |
| Carbondisulfide | | | | x | | | | | | |
| 1,1-dichloro-ethene | | | | x | | | | | | |
| 1,2-dichloro-(2)-ethene | | | | x | | | | | | |
| 1,2-dibromethane | | | | x | | | | | | |
| 1,3-dibromethane | | | | x | | | | | | |
| 1,3-dimethyl benzene | | | | x | | | | | | |
| 1,2-dichlorobenzene | | | | x | | | | | | |
| Benzene | | | | | x | | | | | |
| Hexane | | | | | | | | x | | |
| 3-methyl pentane | x | | | | | | x | | | |
| 1,3,5-cyclohepatatriene | | x | | | | | | | | |
| 1,1,-dichloroethane | | | | x | | | | | | |
| 1,2,-dichloroethane | | | | x | | | | | | |
| Bicyclo/3.2.0/Hepta 2,6/Diene | x | | x | | | | | | | |

x-present
**-ug/l

Table 3 (continued). Volatile Organics Analyses at S.C.R.& D. Bluff Road Site
Results in mg/l unless noted

| VOLATILE ORGANICS (cont.) | Garage Well | W24 | DHEC Sample 5/9/79 | Drums On Site | USEPA Sampling July, 1980 |
|---|---|---|---|---|---|
| Tetrahydrofuran | | x | | | x |
| 1,1,-Trichloroethane | 28** | | x | x | |
| Tetrachlorethene | x | | | | |
| Toluene | | | | x | |
| Trichlorofluromethane | x | | | | |
| Trichloromethane | | | x | | |
| 1,1-dichloro-1-nitro-ethane | | | | | |
| Trichloroethene | | | | | |
| Methyl benzene | | | | | |
| Ethyl benzene | | x | | | |
| 2-butanone | | | | | |
| 2-methyl-1-pentene | x | | | | |
| Thiobismethane | | | | | |
| Carbondisulfide | | | x | | |
| 1,1-dichloro-ethene | | | | | |
| 1,2-dichloro-(2)-ethene | | | | | |
| 1,2-dibromethane | | | | | |
| 1,3-dibromoethane | | | | | |
| 1,3-dimethyl benzene | | | | | |
| 1,2-dichlorobenzene | | | | | |
| Benzene | | | | | |
| Hexane | | x | x | x | |
| 3-methyl pentane | | | | | |
| 1,3,5-cyclohepatatriene | | | x | | |
| 1,1,-dichloroethane | | | | | |
| 1,2,-dichloroethane | | | | | |
| Bicyclo/3.2.0/Hepta 2,6/Diene | | | | | |

x-present but not quantified
**-ug/l

Previous studies by SCDHEC support this conclusion (SCDHEC, 1979). Flashpoint means the minimum temperature at which a liquid or solid gives off sufficient vapor to form an ignitable vapor-air mixture near the surface of the liquid or solid.

A possibility exists that some of the volatile organics occurring in the samples result from the use of PVC solvent glue in well construction. However, due to the extensive period of development and pumping prior to sampling, the use of such solvent is thought to have had neglible effect on the quality of the samples. Previous studies by SCDHEC have shown no volatile organics occurring in PVC wells constructed using PVC solvent glue (SCDHEC, 1979).

Other inorganic parameters (see table 2) are highly variable from well to well. These variations are probably primarily the result of the many different compounds stored on the site.

In summary, the presence of volatile organic compounds, metals, and odor indicate widespread contamination of ground water at the SCR&D Bluff Road site. The contamination appears to be moving primarily in two directions, northeast and southeast at a relatively slow rate due to the gentle hydraulic gradient. There also appears to be slight localized radial movement, as indicated by the presence of volatile organics and in lead upgradient wells. The contamination has the potential to move long distances, causing a large segment of the surficial aquifer to be unfit for use. There is no information available to indicate that there are any wells, with the exception of Campbell's Garage, drilled into the shallow aquifer within nearly a mile (1.6 km) radius of the site. In addition, the shallow ground water probably discharges to Myers Creek, approximately one mile (1.6 km) to the east-northeast or to an unnamed tributary to Myers Creek, approximately one-half mile (.8 km) south-southeast of the site.

Table 2. Ground-Water Analyses at S.C.R.& D. Bluff Road Site.

| Parameters | Garage Well | Well 1 | Well 2 | Well 3 | Well 4 | Well 6 |
|---|---|---|---|---|---|---|
| TDS | 110 | 80 | 40 | 46 | 530 | 210 |
| pH | 5.6 | 5.0 | 5.7 | 5.1 | 5.9 | 5.4 |
| Alkalinity | 6 | 3 | 5 | 5 | 70 | 12 |
| $NH_3$-N | 0.23 | 0.30 | 0.10 | 0.28 | 0.20 | 0.23 |
| $NO_3/NO_2$-N | 5.5 | 4.9 | 0.12 | 1.91 | < 0.02 | 1.01 |
| TKN | 1.50 | 1.20 | 1.0 | 3.7 | | 2.50 |
| T-P | < 0.02 | < 0.02 | 0.06 | < 0.02 | 0.30 | 0.02 |
| Hardness | 25 | 30 | 12 | 17 | 160 | 14 |
| Cl | 11.5 | 12.5 | 6.5 | 9.5 | 85 | 42.5 |
| $SO_4$ | < 10 | < 10 | < 10 | < 10 | 40 | < 10 |
| Flashpoint °F | 160 | 170 | 165 | 155 | 160 | 165 |
| Fluoride | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| TOC | 6.1 | 1.8 | 4.2 | 2.9 | 60 | 4.6 |
| Calcium | 6 | 6 | 3 | 4 | 40 | 20 |
| Mg | 2.2 | 3.3 | 2.0 | 1.8 | 12 | 2.7 |
| Na | 5.2 | 4.4 | 2.1 | 3.3 | 26 | 11 |
| K | 3 | 4 | 3 | 2 | 3 | 2 |
| Arsenic* | < 0.01 | | 0.01 | < 0.01 | 0.01 | 0.01 |
| Ba | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Cd | LDL | LDL | LDL | LDL | LDL | LDL |
| Cr | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 |
| Cu | 0.2 | < 0.1 | 0.1 | < 0.1 | < 0.1 | 0.1 |
| Fe | 0.4 | 0.1 | 15 | 0.1 | 10 | 15 |
| Pb | < 0.05 | < 0.05 | 0.08 | < 0.05 | < 0.05 | 0.09 |
| Mn | < 0.05 | 0.12 | 0.23 | < 0.05 | 1.5 | 0.12 |
| Hg | LDL | LDL | LDL | LDL | LDL | LDL |
| Ni | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| COD | < 5 | 5 | < 5 | < 5 | 82 | < 5 |
| Selenium* | < 0.01 | | 0.01 | < 0.01 | 0.01 | 0.02 |
| Silver | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 |
| Zn | 0.5 | 0.3 | 0.2 | 0.2 | 0.2 | 0.3 |
| C. Hydrocarbons* | LDL | | | | LDL | LDL |
| Endrin | | | | | | |
| Lindane | | | | | | |
| Methoxychlor | | | | | | |
| Toxaphene | | | | | | |
| Org. Phos.* | LDL | | | | LDL | LDL |
| PCB* | LDL | | | | LDL | LDL |
| Hydrocarbons | No | | No | | No | No |
| V. Organics | Yes | Yes | Yes | Yes | Yes | Yes |
| Herbicides* | LDL | | | | LDL | LDL |

Results in mg/l unless noted

LDL-Less than Detection Limits

*-Analysis incomplete for these parameters

Table 2 (continued). Ground-Water Analyses at S.C.R.& D. Bluff Road Site.

| Parameters | Well 7 | Well 8 | Well 9 | Well 10 | Well 11 | W-24 |
|---|---|---|---|---|---|---|
| TDS | 220 | 76 | 42 | 50 | 180 | 160 |
| pH | 5.4 | 5.3 | 6.0 | 5.5 | 5.8 | 5.5 |
| Alkalinity | 10 | 5 | 7 | 6 | 5 | 8 |
| $NH_3$-N | 0.50 | 0.20 | 0.20 | 0.15 | 0.18 | 0.32 |
| $NO_3/NO_2$-N | 0.11 | 2.7 | 1.05 | 0.71 | 0.11 | 0.10 |
| TKN | 4.00 | 2.0 | 2.2 | 1.0 | 1.10 | 1.00 |
| T-P | 0.14 | < 0.02 | < 0.02 | 0.02 | 0.10 | 0.15 |
| Hardness | 15 | 13 | < 10 | 10 | <10 | 26 |
| Cl | 185 | 19.5 | 4 | 6.5 | 30.0 | 5.5 |
| $SO_4$ | < 10 | < 10 | < 10 | < 10 | <10 | 15 |
| Flashpoint, $^oF$ | 160 | >170 | 155 | > 170 | 165 | 170 |
| Fluoride | < 0.1 | 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| TOC | 14.3 | 2.9 | 3.1 | 6.8 | 9.1 | 8.1 |
| Calcium | 5 | 2 | 0.9 | 2 | 2 | 7 |
| Mg | 2.3 | 0.9 | 0.17 | 0.8 | 0.9 | 4.4 |
| Na | 56 | 16 | 10 | 3.9 | 24 | 2.3 |
| K | 3 | 2 | 0.6 | 2 | 2 | 3 |
| Arsenic* | 0.01 | < 0.01 | < 0.01 | 0.01 | 0.02 | 0.02 |
| Ba | 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Cd | LDL | LDL | LDL | LDL | LDL | LDL |
| Cr | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 |
| Cu | 0.1 | 0.1 | < 0.1 | < 0.1 | 0.2 | 0.3 |
| Fe | 11 | 0.9 | 0.3 | 1.1 | 6 | 20 |
| Pb | 0.06 | 0.06 | 0.05 | < 0.05 | 0.11 | 0.14 |
| Mn | 0.26 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | 0.19 |
| Hg | LDL | LDL | LDL | LDL | LDL | LDL |
| Ni | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | 0.1 |
| COD | < 5 | | < 5 | < 5 | < 5 | < 5 |
| Selenium* | 0.02 | < 0.01 | < 0.01 | 0.01 | 0.01 | 0.02 |
| Silver* | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 |
| Zn | 0.9 | 0.7 | 0.4 | 0.3 | 0.4 | 0.4 |
| C. Hydrocarbons* | | LDL | LDL | LDL | | |
| Endrin | | | | | | |
| Lindane | | | | | | |
| Methoxychlor | | | | | | |
| Toxaphene | | | | | | |
| Org. Phos.* | | LDL | LDL | LDL | | |
| PCB* | | LDL | LDL | LDL | | |
| Hydrocarbons | No | No | No | No | | |
| V. Organics | Yes | Yes | Yes | Yes | Yes | Yes |
| Herbicides* | | LDL | LDL | LDL | | |

Results in mg/l unless noted
LDL-Less than Detection Limits
*-Analyis incomplete for these parameters

## RECOMMENDATIONS

While the health effects of the volatile organics detected are not well known nor clearly understood, the owner of the well at Campbell's Garage should be notified of the presence of such compounds in the ground water. The well should be plugged to avoid the any possibility that the water may be consumed.

Prior to considering permitting this facility, an attempt should be made to further define and monitor through time the area of degradation, with particular attention paid to the ultimate fate of the contaminated ground water. The magnitude of the problem is largely unknown and should be determined by the facility owners. Any future waste management activities at the site should be considered in light of the area's susceptibility to contamination. Continued monitoring should be conducted by the owner with periodic check samples taken by SCDHEC. Additional shallow wells should be drilled downgradient to determine the lateral and vertical extent of contamination in the surficial aquifer. At least one deep well should be drilled into the Black Mingo formation and sampled to assess the potential for contamination of the deeper aquifer through recharge from the shallow contaminated aquifer.

The existing well in the warehouse should be properly sampled. An attempt should be made to obtain construction information concerning the well (depth, screen setting, etc.), and the well should then be properly sealed.

Future studies by the USEPA should be better coordinated with appropriate state officials. Such coordination would prevent duplication of effort and better utilize state capabilities (especially drilling) and site-specific knowledge of hydrogeologic conditions.

This site should not be permitted as a hazardous waste storage and treatment facility. The fact that contamination exists indicates that the area is susceptible to contamination and lacks the proper geologic backups such as confining beds and a deep water table.

While it may not be feasible to recover, treat, and properly dispose of all the contaminated ground water, all waste materials and contaminated soil should be removed from the site. Allowing the improperly stored hazardous materials and contaminated soil to remain will intensify the problem and pollute more of the aquifer for longer periods of time. Precipitation will continue to leach contaminants to the ground water, increasing the potential for harmful health effects to users of the shallow unconfined aquifer. This material should be taken to an appropriate facility designed to contain hazardous-waste materials.

## SELECTED REFERENCES

Colquhoun, D.J., 1965, Terrace Sediment Complexes in Central South Carolina, 62 p.

Cooke, C.W., 1936, Geology of the Coastal Plain of South Carolina: U.S. Geol. Survey Bull. 867, 196 p.

___________, 1954, Carolina Bays and the Shapes of Eddies: U.S. Geol. Survey Prof. Paper 254-1, p. iii, 195-207.

Padgett, G.G., 1980, Lithostratigraphy of Black Mingo Formation in Sumter, Calhoun, and Richland Counties: M.S. Thesis, University of South Carolina, Columbia, 68 p.

S.C. Department of Health and Environmental Control, 1979, Lindau Chemicals Incorporated Groundwater Contamination Investigation, 26 p.

___________, 1979, Kalama (Vega) Chemical Company Beaufort County, South Carolina, Groundwater Contamination Investigation, 75 p.

Siple, G.E., 1957, Guidebook for the South Carolina Coastal Plain Field Trip of the Carolina Geological Society, Nov. 16-17, 1957, 27 p.

U.S. Environmental Protection Agency, 1980, Groundwater and Surface Water Investigation, South Carolina Recycling and Disposal, Inc., Bluff Road Site, Columbia, South Carolina, July 1, 1980.